Assessment of Model Outcomes between MEDPRAT & The IMM

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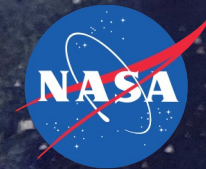Jerry Myers[2]   Michael Lovell[1]

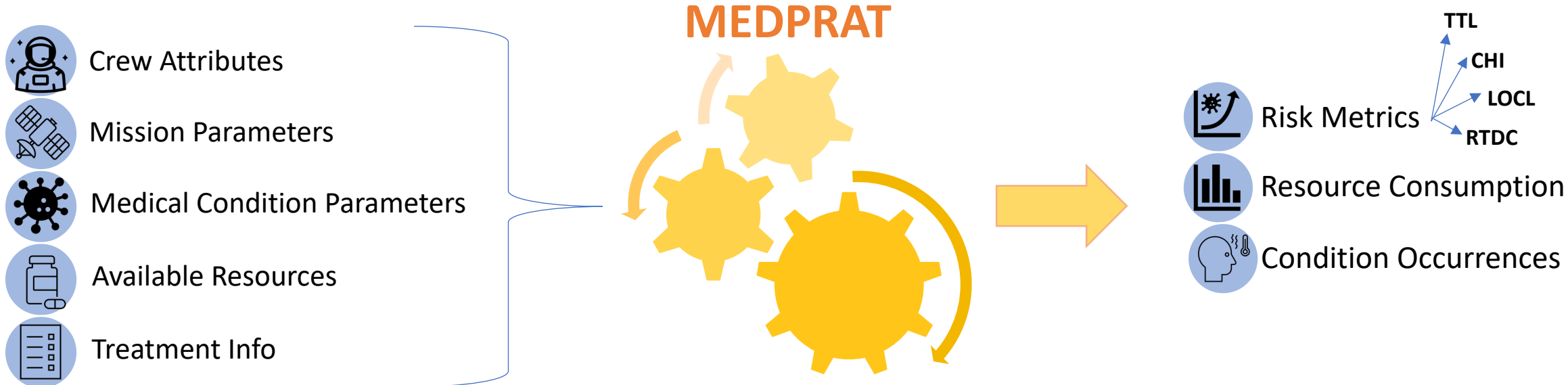[1] BQMI
[2] NASA Glenn Research Center
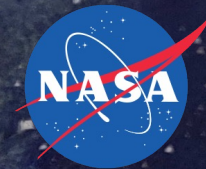[3] ZIN Technologies Inc.

HRP IWS | 02/08/2023

- **M**edical **E**xtensible **D**ynamic **P**robabilistic **R**isk **A**ssessment **T**ool

- Computational model that simulates medical events as they relate to crew health during a mission to characterize space flight human health and performance risks.
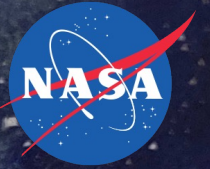

Crew Attributes
Mission Parameters
Medical Condition Parameters
Available Resources
Treatment Info

MEDPRAT

Risk Metrics — TTL, CHI, LOCL, RTDC
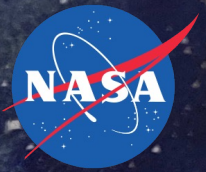Resource Consumption
Condition Occurrences

- The Integrated Medical Model (IMM) is the accepted standard for quantifying spaceflight mission medical risk in NASA operations.

- While MEDPRAT implemented a new, efficient architecture and new capability, it's basic functionality mimics that of the IMM.

- How does the outcome for the same reference missions and input data compare between IMM and MEDPRAT V1 and MEDPRAT V2?

MEDPRAT V1 COMPARED TO THE IMM

| Assumptions	MEDPRAT V1	IMM
Resource Consumption varies between the two models.	Resources are consumed over time and scheduled in the simulation	Resource Consumption is decremented/consumed instantly
MEDPRAT's Fully Treated scenario aligns more with IMM's Limited Treated scenario.	Fully treated scenario reports desired resource counts	Limited treatment scenario reports desired resource counts
MEDPRAT may report higher resource consumption.	"End of mission" prescribed resources are consumed at the given rate until end of mission with no cap.	Resource prescribed "End of mission" are treated like "Per day" and are capped at a certain amount.
IMM will report higher LOCL and RTDC statistics.	If a medical condition can progress to LOCL and RTDC then both are scheduled	If both LOCL and RTDC can happen, then both are reported to occur
Sparse metrics or rare conditions can be noisy with IMM's fewer ran trails (e.g. LOCL).	Highly computationally efficient can simulate millions of trials in a matter of minutes	Procedurally limited to 100k trials

Condition Occurrences – IMM vs MEDPRAT
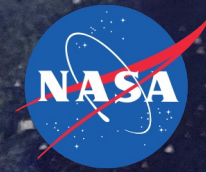
Mission Duration	Number of crew	Number of EVAs
21 days	4	0

- Variation in the confidence intervals due to number of trials difference in a shorter mission

Medical Condition	MEDPRAT Occur_Mean	IMM Occur_Mean
HEADACHE	1.41	1.40
SLEEP DISORDER	1.09	1.12
SKIN ABRASION	0.77	0.79
SKIN RASH	0.77	0.80
CONSTIPATION	0.69	0.68
EYE IRRITATION/ABRASION	0.58	0.59
HEADACHE (CO2 INDUCED)	0.17	0.16
ELBOW SPRAIN/STRAIN	0.10	0.11
ANKLE SPRAIN/STRAIN	0.10	0.09
CHOKING/OBSTRUCTED AIRWAY	0.02	0.03

Medical Conditions with different predicted means (rounded).
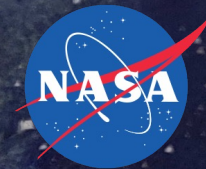

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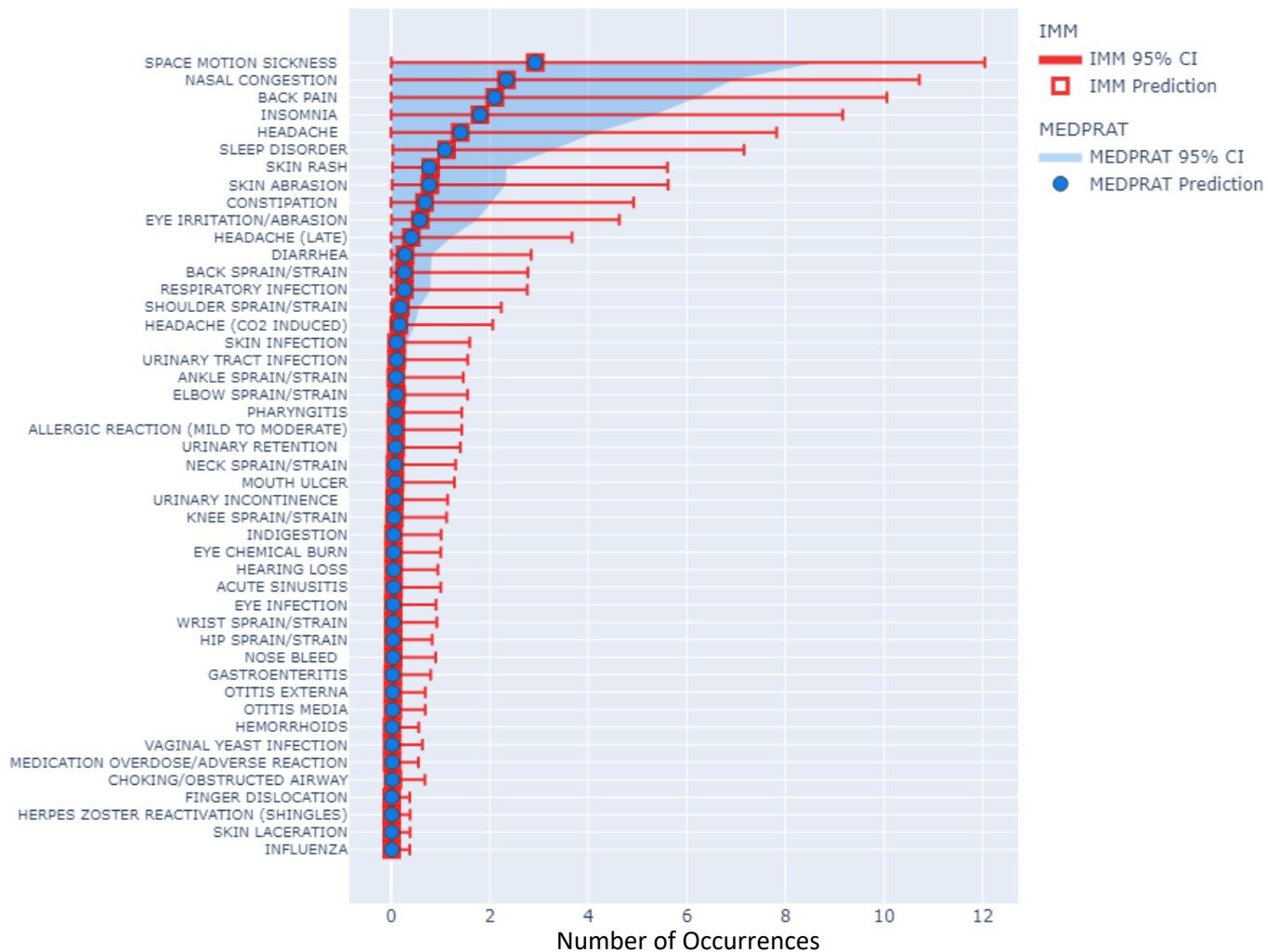
- Difference between the two predicted LOCL means is not statistically significant.

- Remember that MEDPRAT will schedule LOCL and RTDC, but report only the one that occurs first during simulation.

- MEDPRAT results are consistent with IMM results.

	IMM	MEDPRAT V1	IMM SD	MEDPRAT SD
TME	17.68	17.60	3.42	3.38
LOCL	0.00027	0.00008	0.016	0.009
RTDC	0.0022	0.0018	0.047	0.042
CHI	97.13	97.65	1.60	1.17

| Acronym	Mission Level Metrics
TME	Total Medical Events
LOCL	Loss of Crew Life
RTDC	Removal to Definitive Care
CHI	Crew Health Index

- Resources are grouped by Resource Categories developed for IMM used in the RWS Validation.

- MEDPRAT V1 resource quantity means are comparable to IMM resource quantity results.

- Largest difference is only 0.07 for the Other category.

Resource Quantity Means by Resource Category
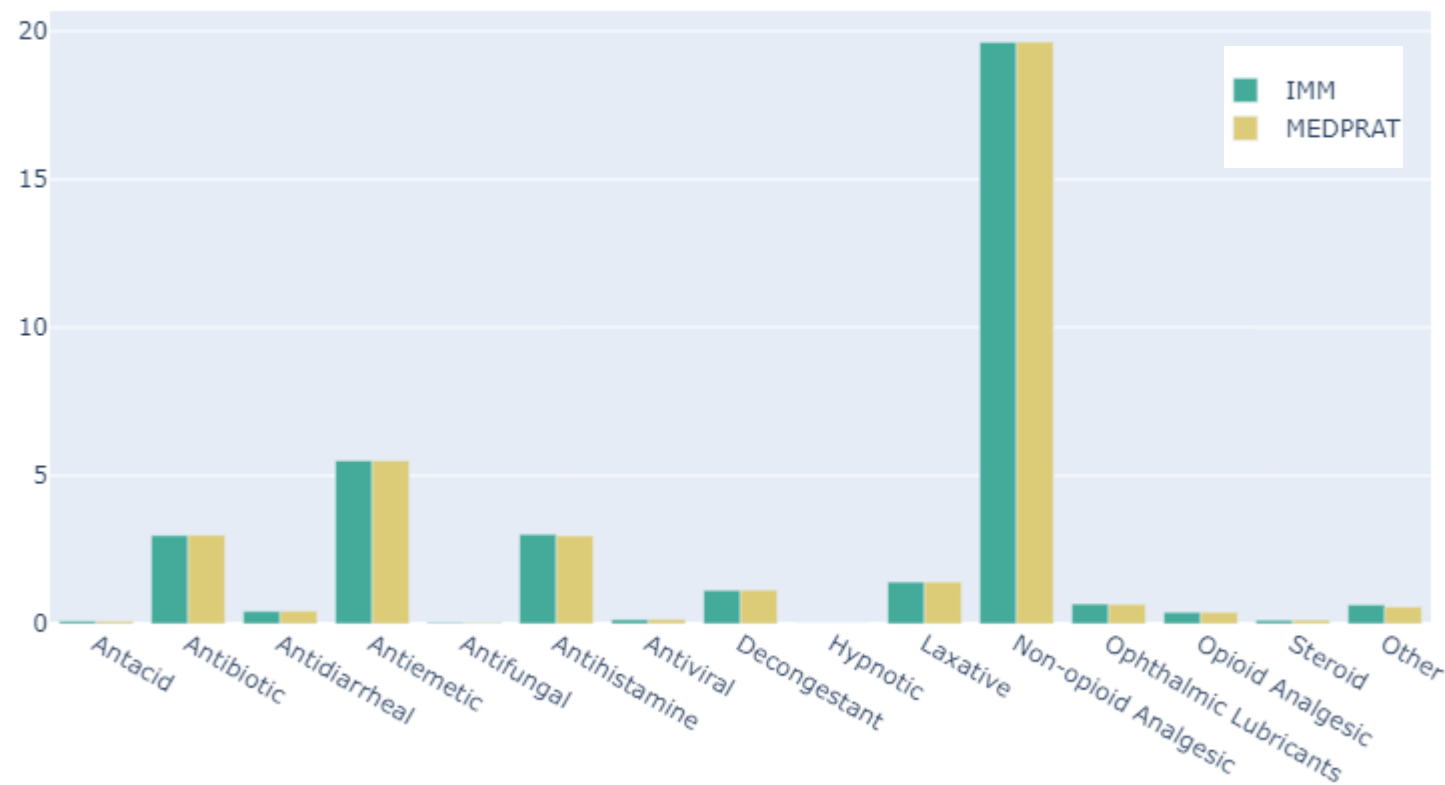
- CHI was prioritized during optimization.

- Slight differences in LOCL and RTDC.

- Overall MEDPRAT can optimize kits that are able to mitigate at least as much risk as IMM kits.

	IMM		MEDPRAT	
	9.07kg mass constraint	9.07kg mass 13721 cm^3 volume constraint	9.07kg mass constraint	9.07kg mass 13721 cm^3 volume constraint
Mass (kg)	9.25	7.76	8.45	5.3
Volume (cm^3)	23594.34	13895.43	18752.02	13130.18

IMM and MEDPRAT Mass and Volume for both optimized medical kits.

	IMM		MEDPRAT	
	9.07kg mass constraint	9.07kg mass 13721 cm^3 volume constraint	9.07kg mass constraint	9.07kg mass 13721 cm^3 volume constraint
CHI	97.2	97.2	97.6	97.6
LOCL	0.0005	0.0005	0.0002	0.0003
RTDC	0.0065	0.0074	0.0024	0.0038

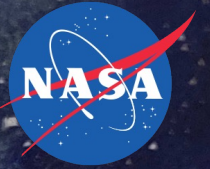**IMM and MEDPRAT CHI, LOCL, and RTDC for both optimized medical kits.**

MEDPRAT V1 provides results consistent with the IMM.

- No large differences in condition occurrences or resource consumption means.

- Despite IMM reporting slightly higher LOCL and RTDC, Mission Level Metrics are very comparable.

- The small differences between MEDPRAT V1 and IMM results are unlikely to change the influence on any subsequent decisions.

- Optimized medical kits results are at least as good.

Running MEDPRAT V1 produces similar predictions to the IMM, the accepted standard for quantifying spaceflight mission medical risk.

MEDPRAT V2 COMPARED TO THE IMM

Additional Assumption: Condition occurrences and resource consumption are expected to reported higher in MEDPRAT V2 predictions.

Should a medical condition occurrence be found to progress to RTDC, it will be scheduled and reported but the crew member will remain in the simulation.

Assumptions in V1 & V2
Resource Consumption varies between the two models.
MEDPRAT's Fully Treated scenario aligns more with IMM's Limited Treated scenario.
MEDPRAT might report higher resource consumption.
IMM will report higher LOCL and RTDC statistics.
Sparse metrics or rare conditions can be noisy with IMM's fewer ran trails (e.g. LOCL).

Mission Duration	Number of crew Performing EVAs	Number of EVAs
860 days	2	15

- Occurrences by condition for which the IMM predicted 1 or more occurrences with MEDPRAT 95% CI.

- MEDPRAT predicted means are very similar to the IMM predicted means and are within the IMM's CI.
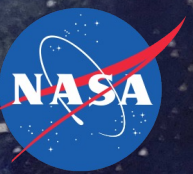

Condition Occurrences – IMM vs MEDPRAT
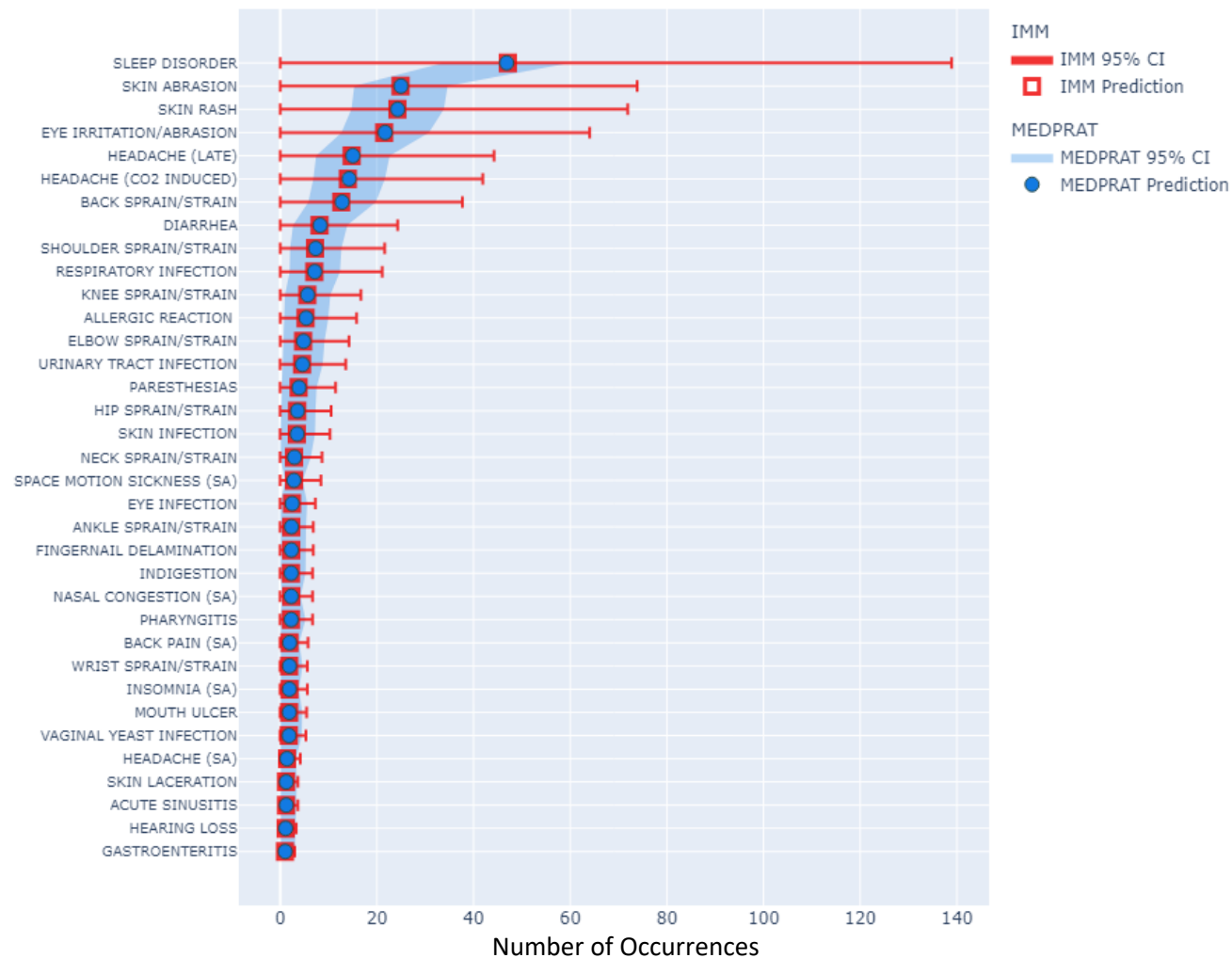
- Occurrences by condition for which the IMM predicted less than 1 occurrences with MEDPRAT 95% CI.

- Predictions for Eye Corneal Ulcer, Barotrauma, and Decompression Sickness are consistent with theoretical mean.

- MEDPRAT results are slightly skewed to the right predicting higher occurrence means per the additional assumption for version 2.
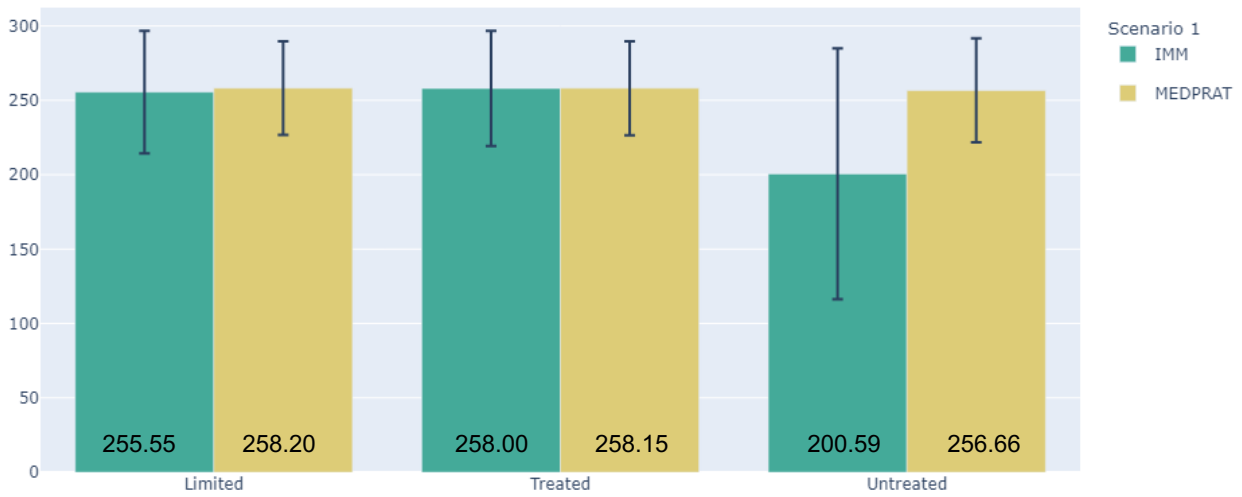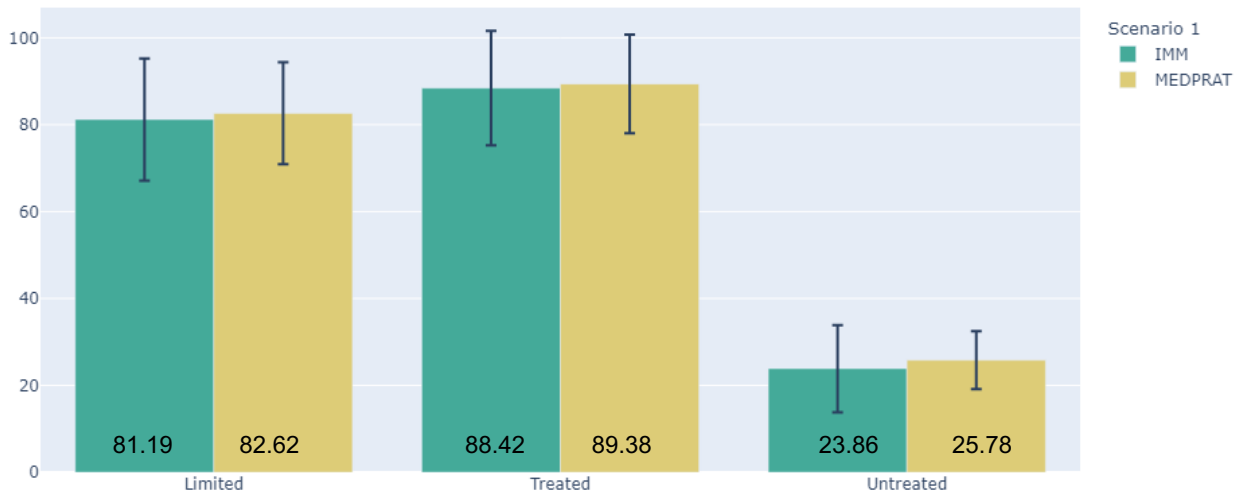

Condition Occurrences – IMM vs MEDPRAT
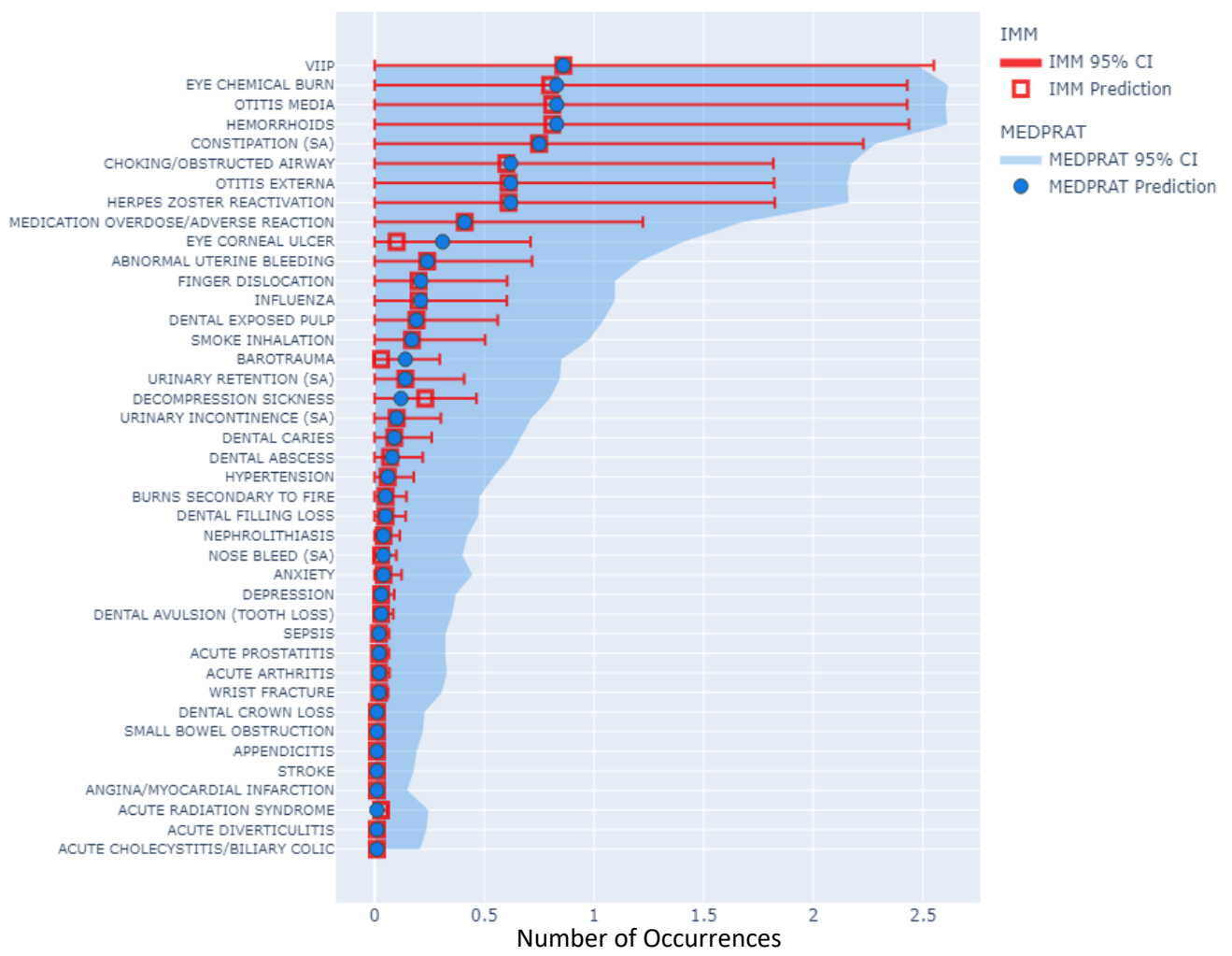
Average TME – IMM vs MEDPRAT

Average TME by treatment for IMM and MEDPRAT with 95% CI.

Average CHI – IMM vs MEDPRAT
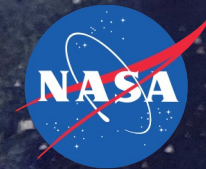
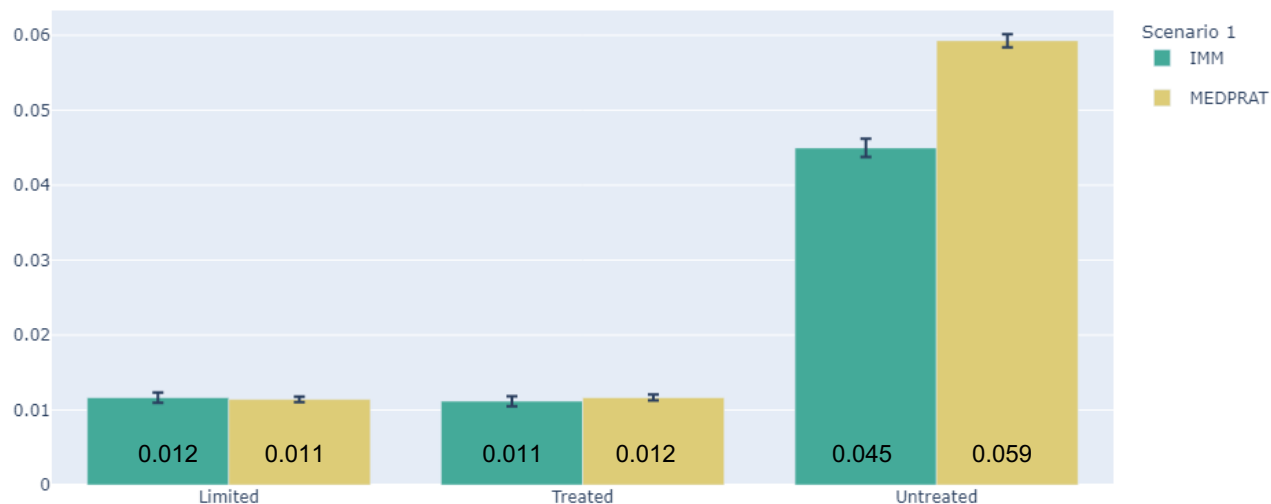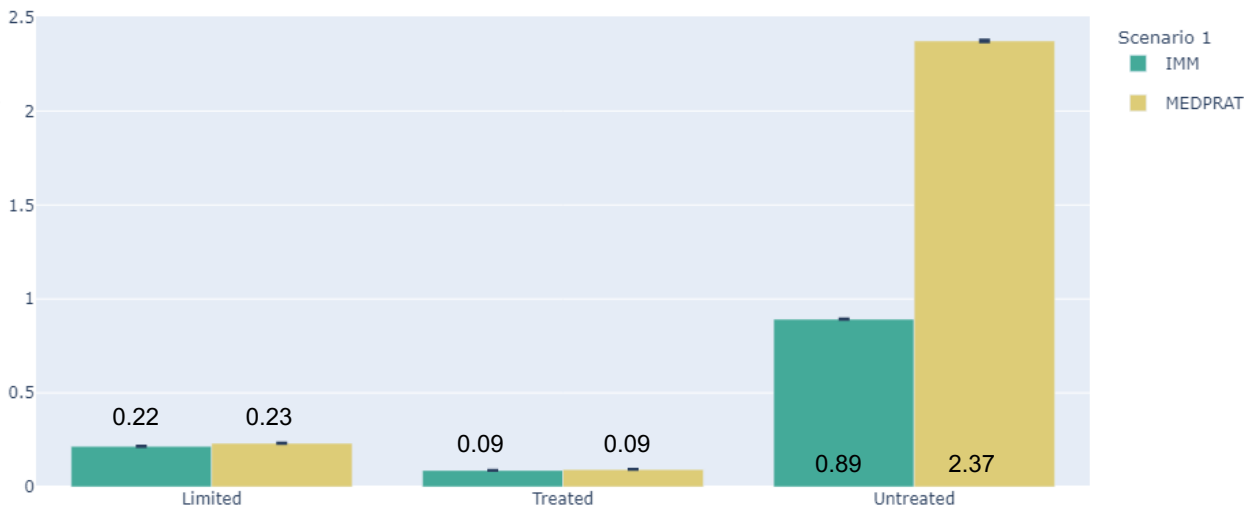Average CHI by treatment for IMM and MEDPRAT with 95% CI.

Probability of LOCL – IMM vs MEDPRAT
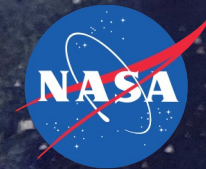

Probability of LOCL by treatment for IMM and MEDPRAT with 95% CI.

Probability of RTDC – IMM vs MEDPRAT

Probability of RTDC by treatment for IMM and MEDPRAT with standard error of the mean.
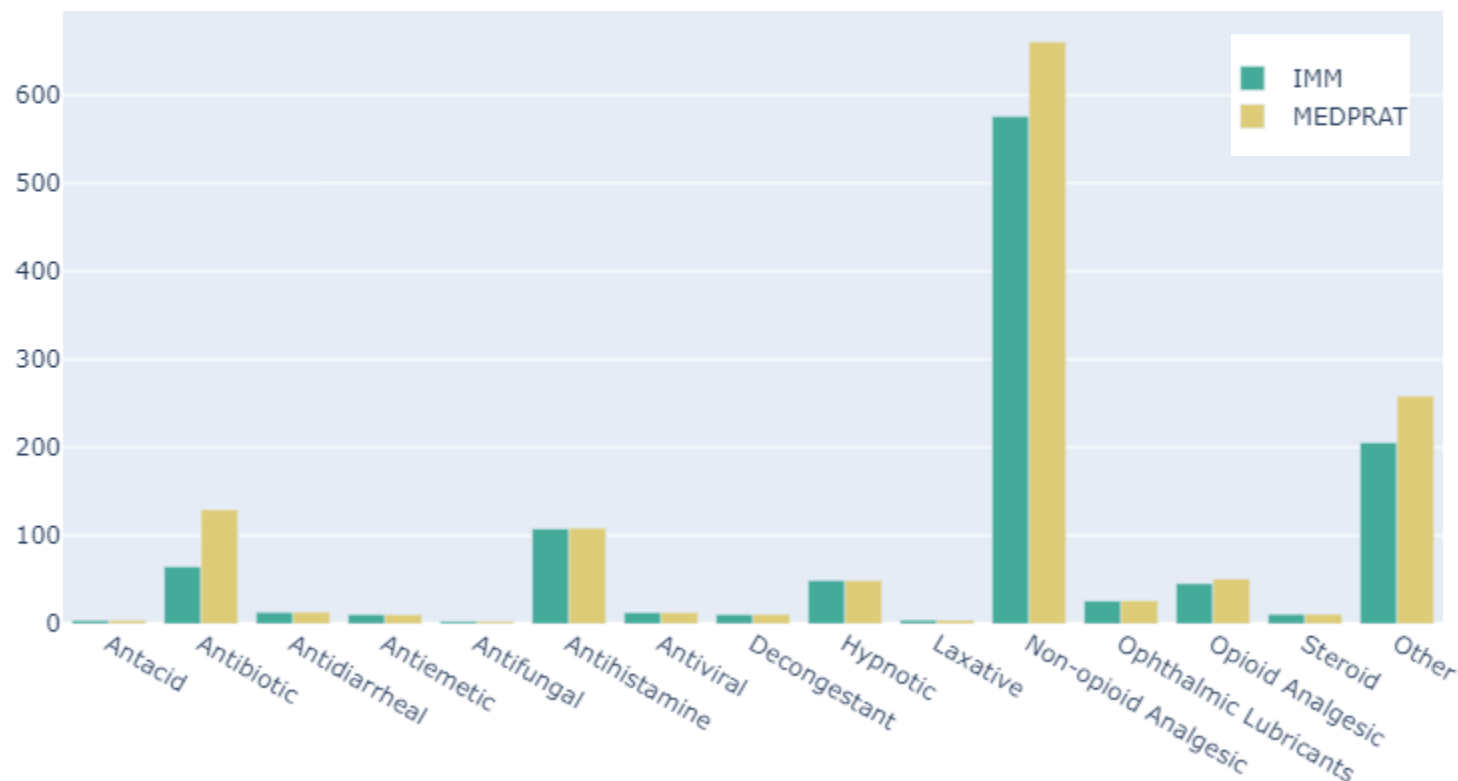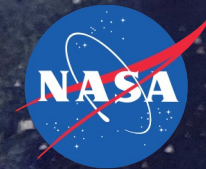
- As expected, MEDPRAT V2 predicts higher resources quantity means compared to the IMM.

- Due to changes in V2 capability crew stay in the simulation even after flagged for RTDC leading to higher resources consumption.

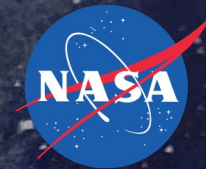Resource Quantity Means by Resource Category

- MEDPRAT V1 predicted similar results as the IMM.

- MEDPRAT V2 provides results with slightly larger difference from the IMM due to differences in assumptions, notably RTDC implementation.

- When comparing MEDPRAT V2 predictions, we see how the same basic principles implemented differently affect the outcome especially in untreated scenario and resource consumption.

Questions?